Kinetics and Structures of Self-assembled Nanocrystal Superlattices

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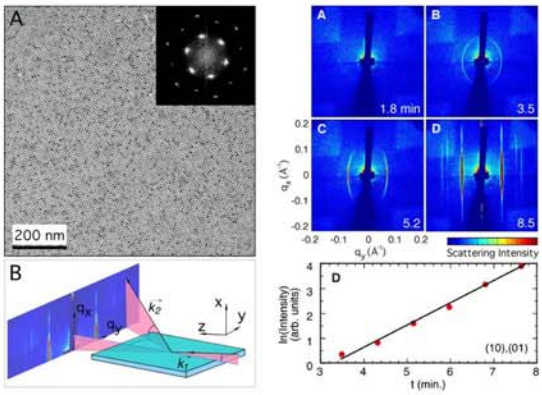
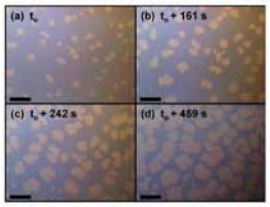
Motivation: Self-assembly of nanocrystals has been considered as one of the promising candidates for making future electronic and optical devices. However, even for the simplest case of drying a nanocrystal colloidal droplet, a variety of self-assembled structures can be formed. This is because colloidal droplet evaporation is a far-from equilibrium process that induces non-uniform mass distributions. Our recent experiments using in situ x-ray and optical microscopy have discovered new insights in controlling Au nanocrystal organization into either 2D and 3D superlattices.

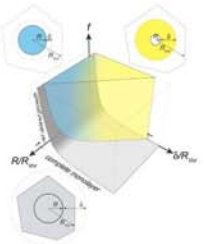
2D

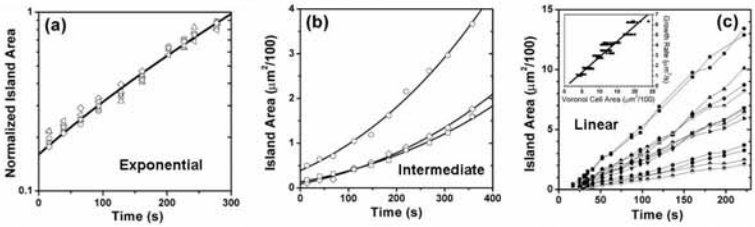
In situ SAXS Experiments



In situ Optical Microscopy



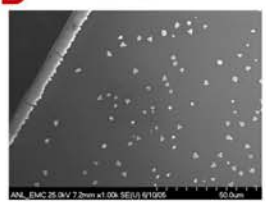




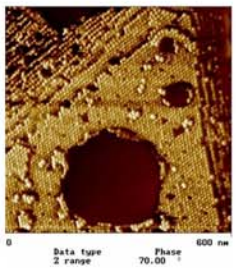
- *In situ* x-ray scattering and optical microscopy show for the first time that self-assembly is controlled by evaporation kinetics and particle interactions with the liqui-air interface.
- 2D nanocrystal superlattices form at the liquid-air interface under fast evaporation rate and strong particle-interface interaction.
- 2D domains grow either in exponential, linear and intermediate growth laws depending on particle flux and interfacial diffusion length.

3D

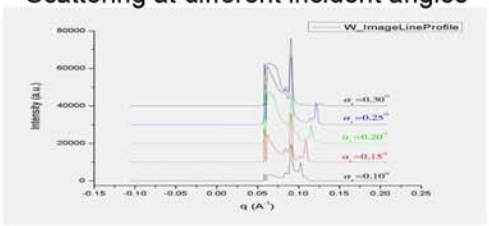
SEM

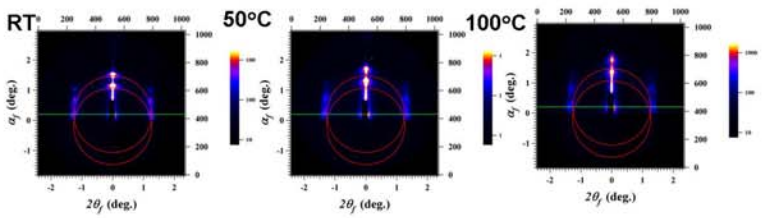


AFM

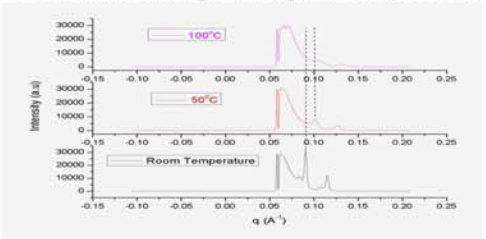


Scattering at different incident angles





Structural change at higher temperature



- 3D nanocrystal superlattices form at the near the substrate under slow evaporation rate and weak particle-interface interaction.
- 3D domains show preferential orientation on the substrate. The lattice spacing decrease at elevated temperature before sintering.

Future Directions:

- Generalize controlled 2D and 3D superlattices formation to a variety of other materials.
- Understand magnetic domain formation in assembly of magnetic nanocrystals.
- Extend electronic transport measurement into magnetic and superconducting superlattices.

T. P. Bigioni, X. M. Lin, T. T. Nguyen, E. I. Corwin, T. A. Witten, H. M. Jaeger, Nature Materials, in press.

S. Narayanan, J. Wang, X.M. Lin, Phys. Rev. Lett. 93, 135503, (2004).

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